

Appl. No. 10/804,708

Attorney Docket No.: TSMC2003-0804(N1280-00050)

Amdt. dated 05/23/2006

Response to Office Action of 03/24/2006

**Amendments to the Claims:**

This listing of claims will replace all prior versions, and listings of claims in the application:

1 1. (Currently Amended) A bandgap reference circuit comprising:  
2 first, second and third current sources (CS1, CS2, and CS3) adjusted to have the  
3 same current, the first current source feeding into a first BJT device module (Q1), the  
4 second current source feeding into a second BJT device module (Q2) through a first  
5 resistor (R1), and the third current source connecting to a grounding voltage supply  
6 through a second resistor (R2);  
7 a current summing circuit;  
8 a first voltage passing unit connecting an output of [[CS1]] the first current source  
9 as its input and connecting its output to a first end of a third resistor (R3) and a first  
10 output of the current summing circuit;  
11 a second voltage passing unit connecting an output of [[CS3]] the third current  
12 source as its input and feeding its output to a first end of a fourth resistor (R4) and a  
13 second output of the current summing circuit;  
14 a fifth resistor (R5) connecting to a third output of the current summing circuit on  
15 a first end and the grounding voltage supply on a second end thereof.  
16 wherein a first current through the fifth resistor [[R5]] bears a substantially linear  
17 relationship with a summation of a second current through the third resistor [[R3]] and a  
18 third current through the fourth resistor [[R4]],  
19 wherein the outputs of the first and second voltage passing units track their  
20 respective inputs, and  
21 wherein by selecting predetermined values for the first, second, third, fourth, and  
22 fifth resistors R1, R2, R3, R4, and R5 in conjunction with selections of the first BJT  
23 device module [[Q1]] and [[Q2]] the second BJT device module, a reference voltage of  
24 the circuit across R5 the fifth resistor is independent of temperature variations.

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1 2. (Currently Amended) The circuit of claim 1 further comprises an operational  
2 amplifier with its positive input connected to the output of the first current source [[CS1]]  
3 and negative input connected with the output of the second current source [[CS2]].

1 3. (Currently Amended) The circuit of claim 1 wherein the current summing circuit  
2 provides the first current through [[R5]] the fifth resistor equal to the summation of the  
3 second and third currents through the third resistor [[R3]] and the fourth resistor [[R4]].

1 4. (Currently Amended) The circuit of claim 1 wherein the second BJT device  
2 module [[Q2]] has a predetermined number of BJT transistors connected in parallel.

1 5. (Original) The circuit of claim 1 wherein the reference voltage is less than or  
2 equal to about 1V.

1 6. (Original) The circuit of claim 1 wherein a supply voltage of the circuit is less than  
2 about 1V.

1 7. (Currently Amended) The circuit of claim 1 wherein the first BJT device module  
2 [[Q1]] is a pnp type and receives the output of the first current source [[CS1]] at its  
3 emitter, and wherein [[Q2]] the second BJT device module is a pnp type and receives  
4 the output of the second current source [[CS2]] at its emitter through the first resistor  
5 [[R1]].

1 8. (Currently Amended) The circuit of claim 7 wherein a predetermined relationship  
2 among an emitter voltage of Q1 ( $V_{be1}$ ) and an emitter voltage of Q2 ( $V_{be2}$ ) may be  
3 expressed mathematically by ~~and the~~  $(R5 / R3) * dV_{be1}/dT + ((R2 * R5) / (R1 * R4)) * d(V_{be1} - V_{be2})/dT = 0$  is zero, wherein  $dV_{be1}/dT$  and  $d(V_{be1} - V_{be2})/dT$  are respective  
4 changes of the emitter voltage of [[Q1]] the first BJT device module and a difference  
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6 between the emitter voltages of the first and second BJT device modules Q1 and Q2  
7 with respect to temperature.

1 9. (Currently Amended) The circuit of claim 1 wherein ~~Q1 and Q2~~ the first and  
2 second BJT device modules have their collectors grounded so that the reference  
3 voltage ( $V_{REF}$ ), an emitter voltage of Q1 ( $V_{be1}$ ), an emitter voltage of Q2 ( $V_{be2}$ ), and the  
4 resistors bear a predetermined relationship as represented mathematically by  $V_{REF} =$   
5  $V_{be1} * (R5 / R3) + (V_{be1} - V_{be2}) * ((R2 * R5) / (R1 * R4))$ .

1 10. (Original) The circuit of claim 1 wherein the first and second voltage passing units  
2 are unit gain buffers.

1 11. (Currently Amended) A bandgap reference circuit comprising:  
2 first, second and third current sources (CS1, CS2, and CS3) with an output of the  
3 first current source [[CS1]] output feeding into a first BJT device module (Q1), an output  
4 of [[CS2]] the second current source feeding into a second BJT device module (Q2)  
5 through a first resistor (R1), and an output of the third current source [[CS3]] connecting  
6 to a grounding voltage supply through a second resistor (R2);  
7 a current summing circuit for providing three current paths to the grounding  
8 voltage supply through third, fourth and fifth three resistors (R3, R4, and R5)  
9 respectively,  
10 wherein the outputs of the first current source [[CS1]] and [[CS3]] the third current  
11 source are buffered and connected to the grounding voltage supply through [[R3]] the  
12 third and [[R4]] fourth resistors respectively,  
13 wherein a temperature independent reference voltage ( $V_{REF}$ ) across [[R5]] the  
14 fifth resistor is generated when an emitter voltage of Q1 ( $V_{be1}$ ), an emitter voltage of Q2  
15 ( $V_{be2}$ ), and the resistors bear a predetermined relationship as represented  
16 mathematically by  $(R5 / R3) * dV_{be1}/dT + ((R2 * R5) / (R1 * R4)) * d(V_{be1} - V_{be2})/dT = 0$ ,  
17 wherein  $dV_{be1}/dT$  and  $d(V_{be1} - V_{be2})/dT$  are respective changes of the emitter voltage of  
18 [[Q1]] the first BJT device module and a difference between the emitter voltages of the

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19 first BJT device module [[Q1]] and the second BJT device module [[Q2]] with respect to  
20 temperature.

1 12. (Currently Amended) The circuit of claim 11 further comprises comprising an  
2 operational amplifier with its positive input connected to the output of the first current  
3 source [[CS1]] and negative input connected with the output of the second current  
4 source [[CS2]].

1 13. (Currently Amended) The circuit of claim 11 wherein the current summing circuit  
2 provides the current through the fifth resistor [[R5]] to be proportional to the summation  
3 of the currents through the third resistor [[R3]] and the fourth resistor [[R4]].

1 14. (Currently Amended) The circuit of claim 11 wherein the second BJT device  
2 module [[Q2]] has a predetermined number of BJT transistors similar to [[Q1]] the first  
3 BJT device module connected in parallel.

1 15. (Original) The circuit of claim 1 wherein the reference voltage is less than or  
2 equal to about 1V.

1 16. (Original) The circuit of claim 1 wherein a supply voltage of the circuit is less than  
2 about 1V.

1 17. (Currently Amended) The circuit of claim 1 wherein [[Q1]] the first BJT device  
2 module is a pnp type and receives the output of [[CS1]] the first current source at its  
3 emitter, and wherein the second BJT device module [[Q2]] is a pnp type and receives  
4 the output of the second current source [[CS2]] at its emitter through the first resistor  
5 [[R1]].

1 18. (Currently Amended) The circuit of claim 1 further comprises first and second unit  
2 gain buffers setting voltages across [[R3]] the third resistor and [[R4]] the fourth resistors

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Response to Office Action of 03/24/2006

3 by passing the outputs of the first current source [[CS1]] and the third current source  
4 [[CS3]].

1 19. (Currently Amended) A method for generating a temperature independent  
2 reference voltage, the method comprising:

3 generating first, second and third current outputs (CS1, CS2, and CS3), with the  
4 first current source [[CS1]] feeding into an emitter of a first pnp BJT device module (Q1),  
5 the second current source [[CS2]] feeding into an emitter of a second pnp BJT device  
6 module (Q2) through a first resistor resistor (R1), and the third current source [[CS3]]  
7 connecting to a grounding voltage supply through a second resistor resistor (R2);

8 providing three current paths from a current summing circuit to the ground  
9 voltage supply through third, forth and fifth three resistors (R3, R4, and R5) respectively;

10 imposing an emitter voltage of Q1 ( $V_{be1}$ ) across the third resistor [[R3]];

11 imposing a voltage across [[R2]] the second resistor to be across the fourth  
12 resistor [[R4]],

13 wherein a temperature independent reference voltage ( $V_{REF}$ ) across the fifth  
14 resistor [[R5]] is generated when  $V_{be1}$ , an emitter voltage of Q2 ( $V_{be2}$ ), and the resistors  
15 bear a predetermined relationship as represented mathematically by  $(R5 / R3) * dV_{be1}/dT + ((R2 * R5) / (R1 * R4)) * d(V_{be1} - V_{be2})/dT = 0$ , wherein  $dV_{be1}/dT$  and  $d(V_{be1} - V_{be2})/dT$  are respective changes of the emitter voltage of [[Q1]] the first pnp BJT device  
17 module and a difference between the emitter voltages of [[Q1]] the first pnp BJT device  
18 module and [[Q2]] the second pnp BJT device module with respect to temperature.

1 20. (Currently Amended) The method of claim 19 further ~~comprises~~ comprising  
2 using an operational amplifier with its negative input connected to the first current  
3 source [[CS1]] and positive input connected with the second current source [[CS2]] for  
4 maintaining a same current through the first pnp BJT device module [[Q1]] and the  
5 second pnp BJT device module [[Q2]].

Appl. No. 10/804,708

Attorney Docket No.: TSMC2003-0804(N1280-00050)

Amdt. dated 05/23/2006

Response to Office Action of 03/24/2006

1 21. (Currently Amended) The method of claim 19 wherein the current summing  
2 circuit provides the current through [[R5]] the fifth resistor to be proportional to the  
3 summation of the currents through the third resistor [[R3]] and the fourth resistor [[R4]].

1 22. (Currently Amended) The method of claim 19 wherein the reference voltage is  
2 less than or equal to about 1V.